

# CMPUT 275 Final Project: Digital Synthesizer

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# 1 Overview

This project is a two-oscillator digital synthesizer. The synth has a GUI that can be accessed by running the following command within the client directory.

```
python3 seq_interface.py
```

This command will launch the GUI program and allow one to use the Synth in a simple graphical setting. The Synth is a package and can be used without the GUI in other python programs. The Synth supports audio playback from speakers if the package `alsaaudio` is installed on the device. Because of playback's dependency on this package, playback is only supported on Linux machines. However, not having `alsaaudio` installed does not break usability of the Synth as recording output to a `.wav` is supported.

## 2 Installing alsaaudio

Alsaaudio's web page can be found here:

```
https://larsimisch.github.io/pyalsaaudio/
```

As well, the download for the package itself can be found here:

```
https://pypi.python.org/pypi/pyalsaaudio
```

Finally the instructions for installing here:

```
https://larsimisch.github.io/pyalsaaudio/pyalsaaudio.html#installation
```

Installation requires downloading the package, extracting, navigating to the folder's directory, and then following the instructions they detail on the site.

## 3 Synth

The Synth has two wave-table oscillator's that generate the audio stream. We choose wave-table oscillator's as it allows one to generate an arbitrary waveforms. This adds a bunch of functionality to the Synth by not limiting the user to a few select wave forms.

### 3.1 Wavetables

Wave-tables included in this program were all either generated by us using a classical oscillator or created within Xfer's Serum using the wave table editor, no wave-tables included were created by a third-party. Information on serum and how the wave-table editor works is here:

```
https://www.xferrecords.com/products/serum
```

A wave-table is a three dimensional array of data. The "x-axis" is the sample number; the "y-axis" the amplitude; and the "z-axis" the wave-table position. This allows you to modify the sound by automating the wave-table position (Modulation will be covered latter) or just select the perfect waveform from some .wav file. The wave-tables we use are merely a .wav file that we load each complete chunk of 2048 samples. These chunks are known as frames and correspond to the wave-table position (frame 0 = wave-table position 0). Because this loads each complete block of 2024 .wav files specifically meant to be a wave-table is not necessary, they can be any .wav file as long as it contains at least 2024 samples.

## 3.2 Oscillator's

The oscillator's are what produce the initial audio stream. Selecting the wave-table will be covered in the GUI section. The oscillator's have the following control's:

1. Detune
2. Volume
3. Wave-table Position
4. Phase Offset

**Detune:** Allows you to offset the frequency of the Oscillator from the root note(the note being provided by the sequencer) by  $\pm 24$  semitones, 12 semitones is an octave.

**Volume:** Allows you to change the volume.

**Wave-table Position:** Allows you to change the wave-table position.

**Phase Offset:** Allows you to choose the initial phase, aka the starting position of the waveform.

## 3.3 Envelopes

Envelopes shape the sound with amplification modulation. The type of envelopes we are using are called ADSR envelope's, which stands for Attack Decay Sustain Release. The envelope's have the following control's:

1. Attack
2. Decay
3. Sustain
4. Release

**Attack:** Determines the amount of time the input signal will take to rise from 0 to 100% amplification in seconds.

**Decay:** Determines the amount of time the input signal will take to fall from 100 to (sustain amplification)% amplification in seconds.

**Sustain:** Determines the amplification of the sustain. Sustain time automatically scales to fill any remaining time ADR do not cover.

**Release:** Determines the amount of time the input signal will take to fall from (sustain amplification) to 0% amplification, in seconds.

### 3.4 Filter's

The filter's will filter out certain frequency's depending on type of filter selected. There are two type's of filter within this project, High-Pass and Low-Pass. Both these filter's are first-order RC filter's meaning they attenuate frequency above(Low-Pass) and below(High-Pass) the cut-off frequency with a slope of  $-20\text{Db/dec}$  in the magnitude-frequency Bode-Plot. Selecting the filter type will be covered in the GUI section. The filter's have the following control's:

1. Cut-off

**Cut-off:** Allows you to change the cut-off frequency.

### 3.5 LFO's

The LFO or low frequency oscillator generates a value from -1 to 1 using classical oscillator's. It has three wave-forms: *sin*, *square*, *saw*. These are using to oscillate (modulate) parameter's, based on the output of the LFO, of anything control on a device within the Synth including it's self, however that would be pointless. Selecting the device and control will be covered in the GUI section. The LFO's have the following control's:

1. speed
2. Amount
3. Offset
4. Wavetype

**Speed:** Determines the frequency the LFO operates at.

**Amount:** Determines the amount of output that is passed into the control.

**Offset:** Offset's the output of the LFO by this amount.

**Wavetype:** Determines which waveform the LFO uses.

## 3.6 Voicing

This Synth is capable of producing multiple voices, however they are not implemented yet as multiple voice mixing is not ready yet. Voicing is used for generating a note of the sequence. Meaning once multi voice mixing is implemented the Synth will be polyphonic instead of monophonic.

## 3.7 Structure of Synth

The Synth contains two Oscillator's generating in parallel, each of which feed into an envelope. These two audio streams are then mixed and passed through the filter's in series allowing you to create a bandpass filter by combining low and high pass filter's. The Synth contains three LFO's that run independently and modify their parameter at the beginning of every sample generation. The overall structure of the Synth is as follows:

1. Update LFO's
2. Oscillator's
3. Envelope's
4. Mix audio streams
5. Filter1
6. Filter2
7. Output

# 4 GUI

The GUI contains widget's for all the Synth's devices all of which have the ability to be disabled and contain the respective controls outlined in the Synth section as dials. Oscillator's have a button that opens a menu containing all the file's found within the wavetables directory, selecting these will load the wave-table into the oscillator. Filter's have a button that switches between the type of filter. LFO's have three button's the first selects the device to modulate with a pop-up menu. The second chooses the control with a pop-up menu. Not selecting a control will not link the LFO. The third toggles retrigger, meaning the LFO will reset to phase = 0 when a note starts. Otherwise it oscillates continuously.

## 4.1 Step Sequencer

The GUI contains a step sequencer that is used to generate output within the GUI. Lowest note on the sequencer is INSERT and the highest is INSERT, however the oscillator's are able to generate notes from A0 to A10.

## 4.2 Using the Sequencer

The y-axis of the plot corresponds to the note and the x-axis corresponds to time. Step time is controlled by the "Speed" dial to the right of the sequencer, whose value corresponds to seconds.

### 4.2.1 Placing Notes

Notes can be placed and removed by clicking the mouse 1 button on the desired step. Creating notes that span multiple steps can be created by clicking the mouse 1 button on the initial step and while holding the mouse 1 button and moving along the track to the right. Removing them is done in the same manner just selecting the last step and moving to the left. Notes spanning more than one step can be divided by selecting the step you want the split to occur.

## 4.3 Output

To generate output click the render button to the right of the sequencer. The output will render whichever output types you have enabled.

### 4.3.1 Output Types

There are two types of output: Playback and Record. Both of which can be enabled/disabled using the respective buttons to the right of the sequencer, light grey indicates enabled. Playback will output the sound to the speakers and record will output the sound to a .wav file called output.wav within the client directory. If this already exists the file will be replaced.